Research on tactile sensors based on low-dimensional composite material-based bilayer capacitance

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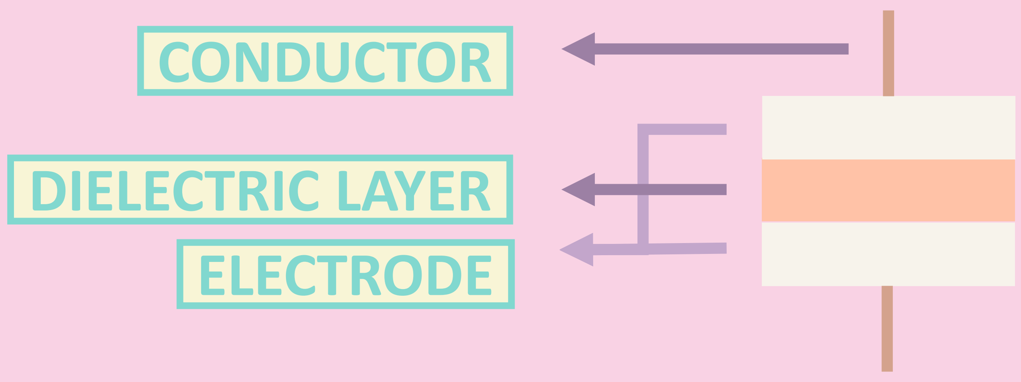
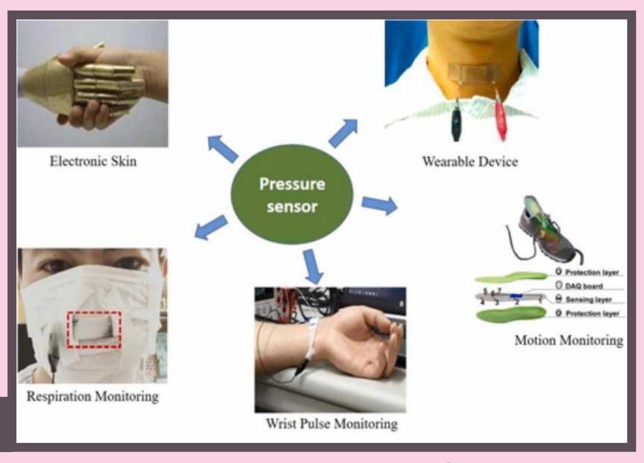
ABSTRACT

Tactile sensors are electronic components that can perceive environmental information, such as the surface features of objects, and function as a significant medium between the external environment and various devices. With the intensive application of the sensors, there has been extreme growth in the requirements for sensor qualities. This research project focuses on exploring the working principles of tactile sensors based on novel principles utilizing composite materials. Furthermore, we probed into the fabrication and measurement methods of the sensor based on bilayer capacitance and put these methods into practice in the laboratory.

1 INTRODUCTION

Compared with traditional tactile sensors, The **Capacitive-type flexible tactile sensors** are commonly chosen as sensing devices in tactile perception systems due to their advantages. These sensors typically have a trilayered structure, with two **electrodes** enclosing a **dielectric layer**.



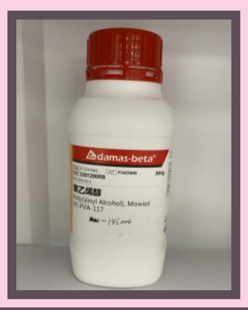


[3]

Here, we report a bilayer capacitive tactile sensor that consists of **ITO-PET** (indium tin oxide-polyethylene terephthalate) electrode and **PVA** (Polyvinyl alcohol) microstructure dielectric layer, where the ITO-PET electrode could lead to the electric double layer (EDL) effect. As a result of the combined impact of the microstructured surface and EDL effect, the performance of capacitive tactile sensors can be significantly enhanced[1].

2 METHOD

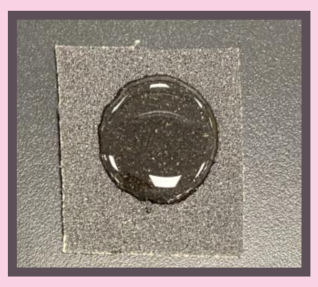
FABRICATION


PVA Particles

Dissolve in deionized water at 80℃

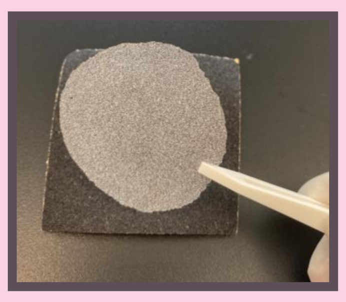

PVA Solution

Pour on sandpaper


Uncured ionic liquid

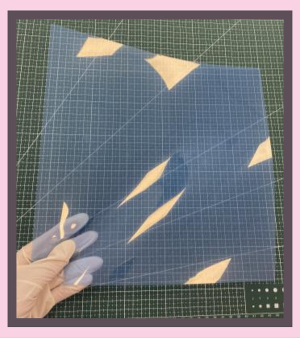
Dry in the drying oven

Peel off


Dielectric Layer

Cut

Encapsulate with tape


ITO-PET Electrode

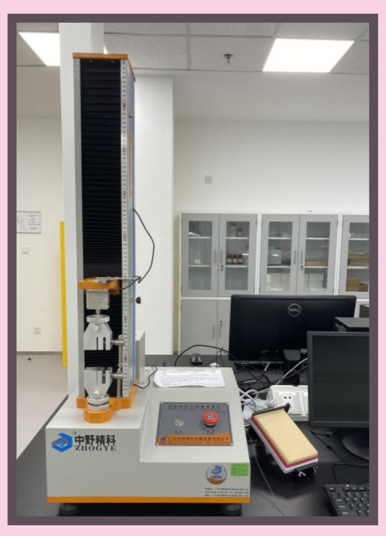
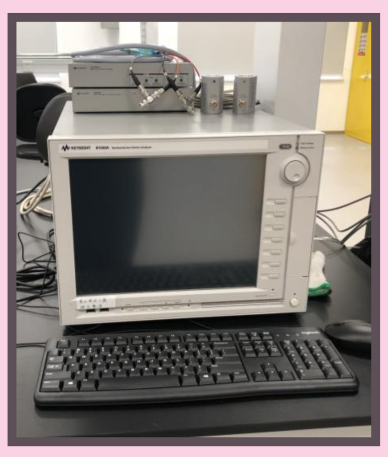
Cut, Ultrasound cleaning


Dielectric


Electrode


Tactile Sensor

MEASUREMENT

APPARATUS	MICROSCOPE	FORCE GAUGE	KEYSIGHT B1500A
FIGURE			
USAGE	Observe the microstructure	Apply a force on the sensor	Collect output capacitance

3 RESULT & DISCUSSION

DESIGN PRINCIPLE

Sensitivity is one of the most important parameters for tactile sensors. Due to the microstructure texture obtained by curing ionic liquid on sandpaper. When pressure is applied to the sensor, the contact area between the electrode and the dielectric layer can be dramatically increased, leading to significant improvement in the sensitivity.

Besides, ionic gels (PVA and ITO-PET) with high sensing quality and conductivity are chosen as basic materials to fabricate the tactile sensor. Such materials could enhance the critical parameters of a tactile sensor.

SENSING PERFORMANCE

The measured parameters and their definitions are shown in the following table:

Sensitivity	The change of capacitance divided by applied pressure
Linearity	Extent of how the sensitivity is close to a straight line
Detection Range	Highest and lowest limitation the sensor can detect
Response Time	Reaction Time when tactile sensor react to applied force
Stability	Parameter used to evaluate durability in long period

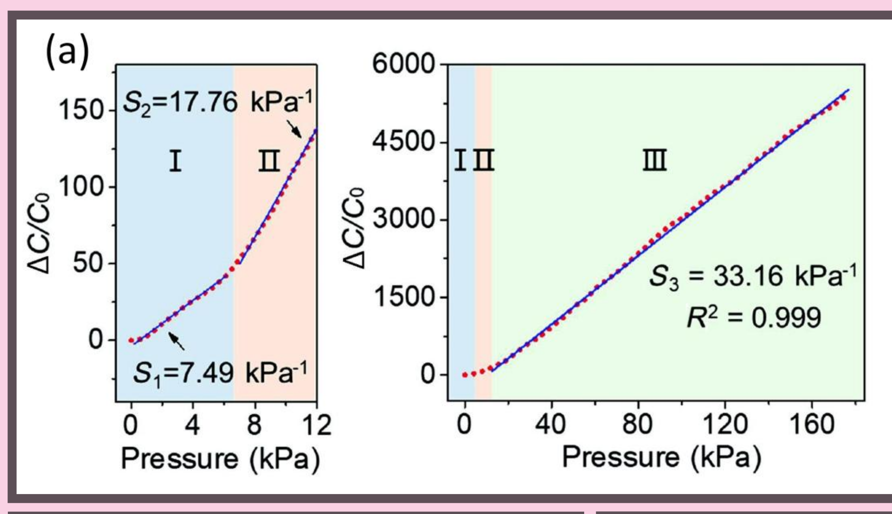


Figure. (a). Change in capacitance as a function of pressure in a specific pressure range [2]

In Figure (a) from Ref.2, **Sensitivity** is equal to the slope of the function, and **Linearity** can be measured by observing the curve in the figure.

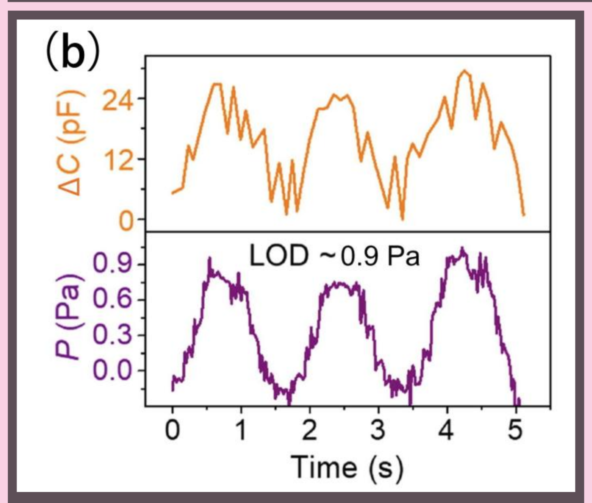


Figure (b). Limit of detection (LOD) [2]

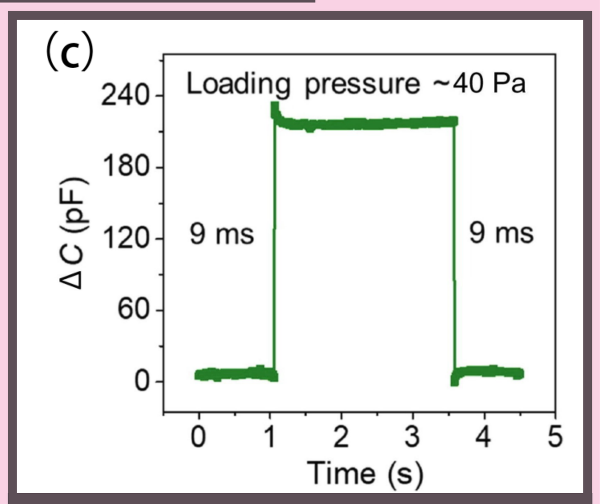


Figure. (c). Response time test [2]

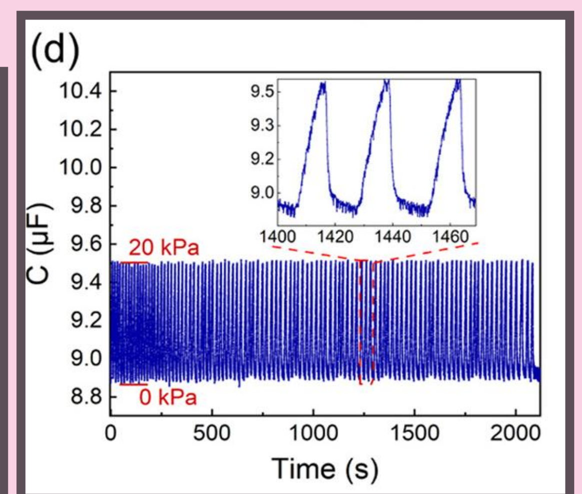


Figure. (d). Stability of the sensor tested over cycles under pressure[1]

By means of combining the lowest LOD with the highest limitation in Figure (a), the **Detection Range** can be calculated.

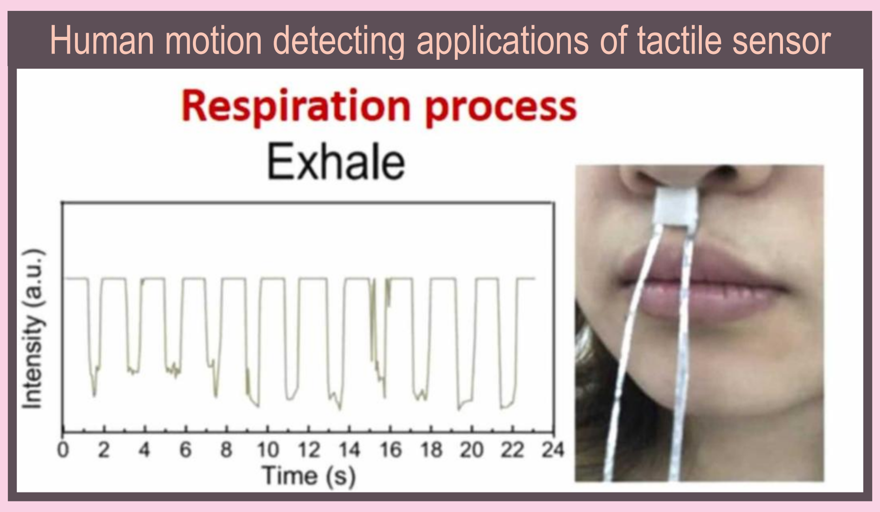
When applying a single force on tactile sensors, capacitance changes in time could be used to measure **Response Time.**

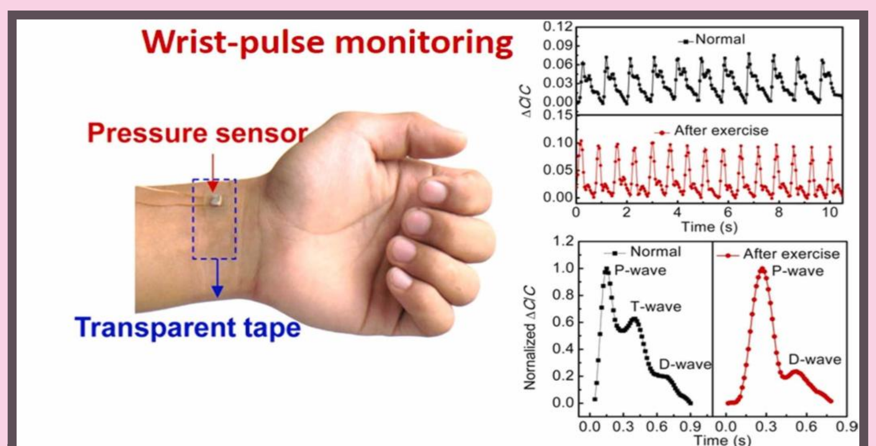
The **Stability** is measured by applying and relieving the same force in a cycle. This parameter is crucial in practical application.

EXPECTED APPLICATION

Here are two primary application domains of tactile sensors reported in **Ref.3**:

Human motion detecting applications of tactile sensor





Application of sensing device in healthcare monitoring

4 CONCLUSION

In this research, we explored the basic principles of the bilayer capacitive tactile sensor. Besides, we found methods to fabricate the sensor and measure its parameters, which were then applied in the laboratory. Consequently, this SURF project's research outcomes and learning benefits are satisfactory.

REFERENCES

1. Zhang, M., et al., Flexible Wearable Capacitive Sensors Based on Ionic Gel with Full-Pressure Ranges. ACS Appl Mater Interfaces, 2023. 15(12): p. 15884-15892.
2. Lu, P., et al., Iontronic pressure sensor with high sensitivity and linear response over a wide pressure range based on soft micropillared electrodes. Sci Bull (Beijing), 2021. 66(11): p. 1091-1100.
3. Bijender and A. Kumar, Recent progress in the fabrication and applications of flexible capacitive and resistive pressure sensors. Sensors and Actuators A: Physical, 2022. 344.

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